Life Cycle Emissions of Different Vehicle/Fuel Technology Pathways

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Presented to: Illinois Commerce Commission

Steffen Mueller, PhD
Principal Economist
UIC Energy Resources Center

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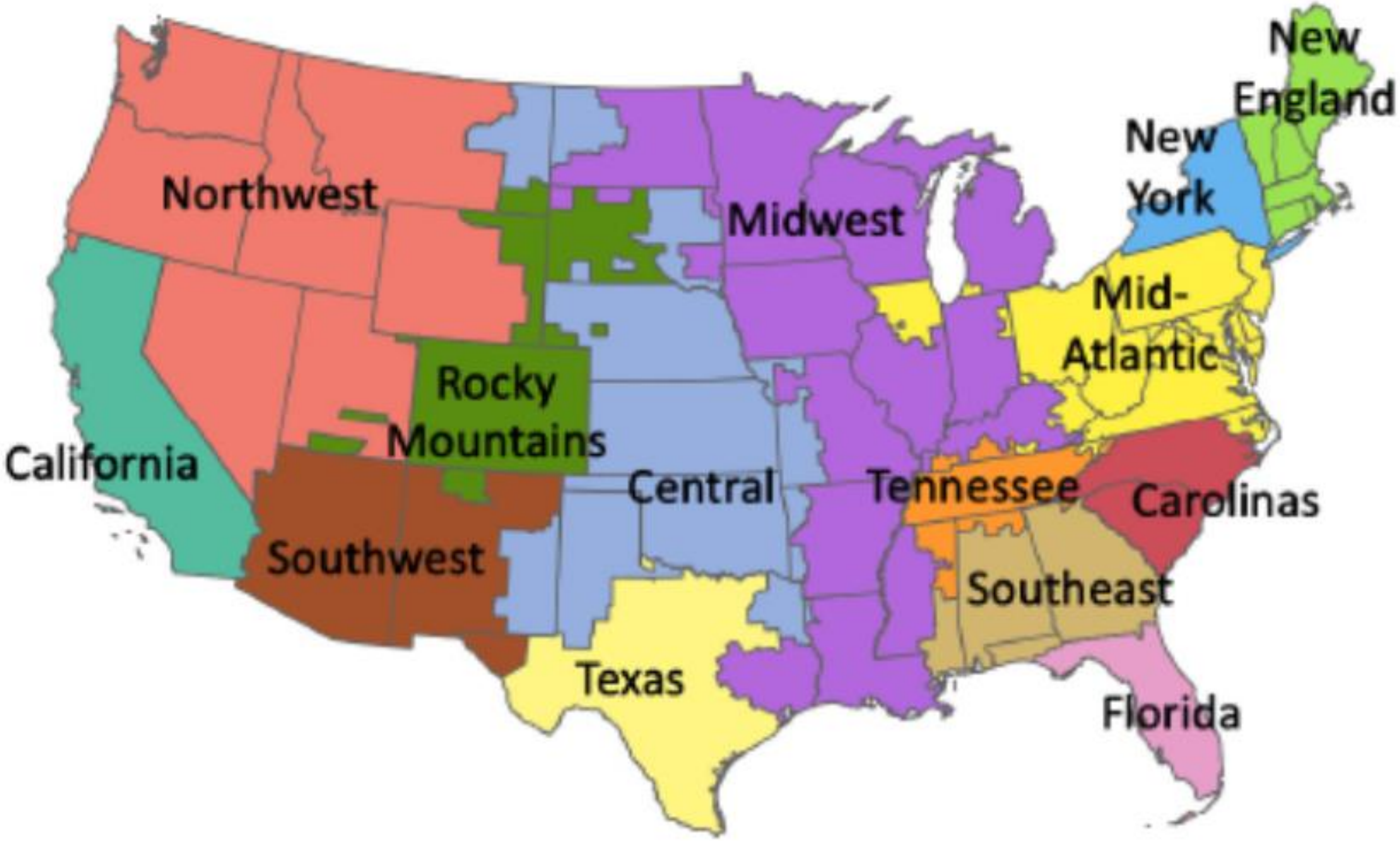
Selected Bio Background

- **2001-Present** Principal Economist, University of Illinois Chicago, Energy Resources Center
- **2021-2022** National Academies of Sciences Committee on “Current Methods for Life Cycle Analyses of Low-Carbon Transportation Fuels in the United States”
- **2014-present** Board Member, International Sustainability and Carbon Certification (ISCC), 2009-2011 Member Expert Working Group. Development of CA Low Carbon Fuel Standard
- **2009-2011** Special Term Appointment Faculty Appointee, Argonne National Laboratory, Transportation Technology R&D Center
- **2005** Co-authored the technical background document behind the Illinois Renewable Portfolio Standard for the Illinois Department of Commerce and Economic Opportunity.
- **1997-2001** Polsky Energy / Calpine Corporation, Director Business Development, Power Plant Development.

Electric Dispatch Regions (AVERT)

Northern Illinois is Connected to Different Dispatch Region than Southern Illinois



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Commonly Used Models

- US Environmental Protection Agency AVERT Model (AVoided Emissions and geneRation Tool)
- US Environmental Protection Agency eGRID Database
- US Department of Energy GREET Model (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model)
- EPA MOVES Model (MOtor Vehicle Emission Simulator)

Introduction: Life Cycle Emissions Modeling of Different Vehicle/Fuel Technologies

Consider transmission loss, upstream emissions include fossil fuel extraction (for both gasoline refineries and power plants)

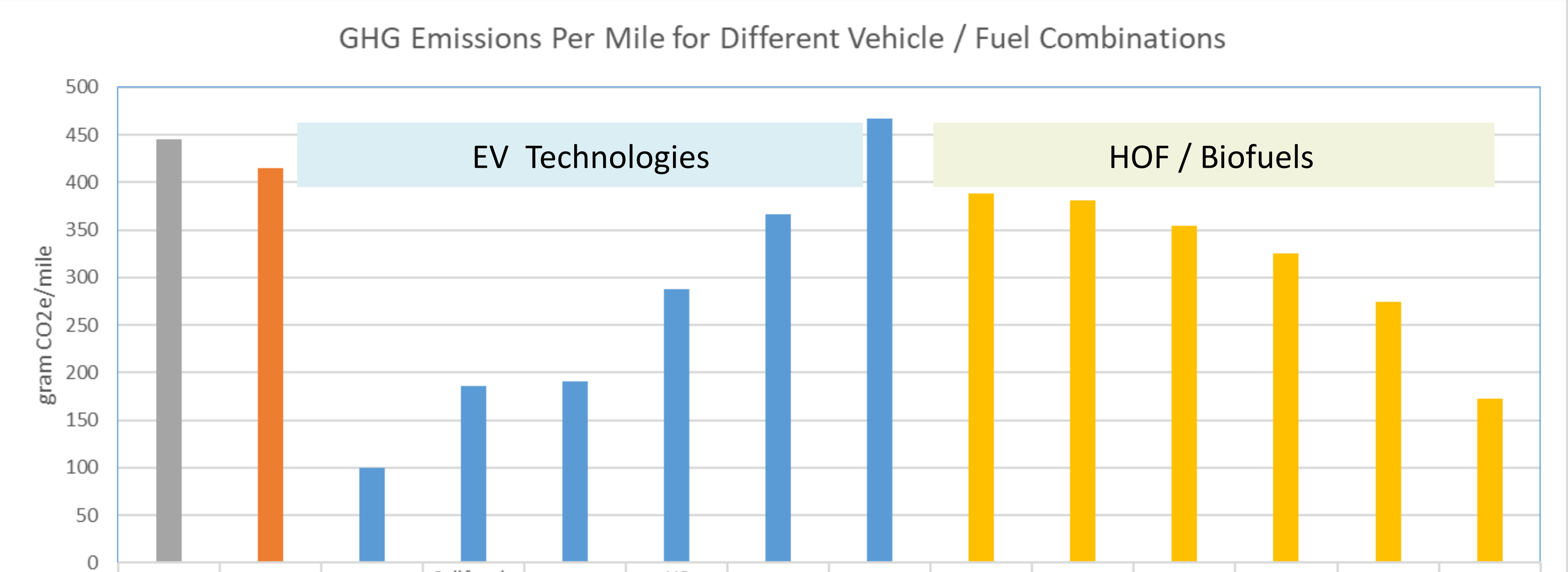
Life Cycle Greenhouse Emissions Assessments:

- Two Metrics
  - gCO2e/mile
  - gCO2e/Megajoule of energy in the fuel

Criteria Pollutants (NOx, SOx, PM, Sulfur, Aromatics, etc.)

- EVs
  - Power Plant Emissions plus Upstream
  - Tire & Break Wear Emissions
- Liquid Fuels (gasoline, gasoline ethanol blends)
  - Refining Emissions plus Upstream
  - Tailpipe Emissions
  - Tire& Break Wear Emissions

Gasoline and EV and Biofuels



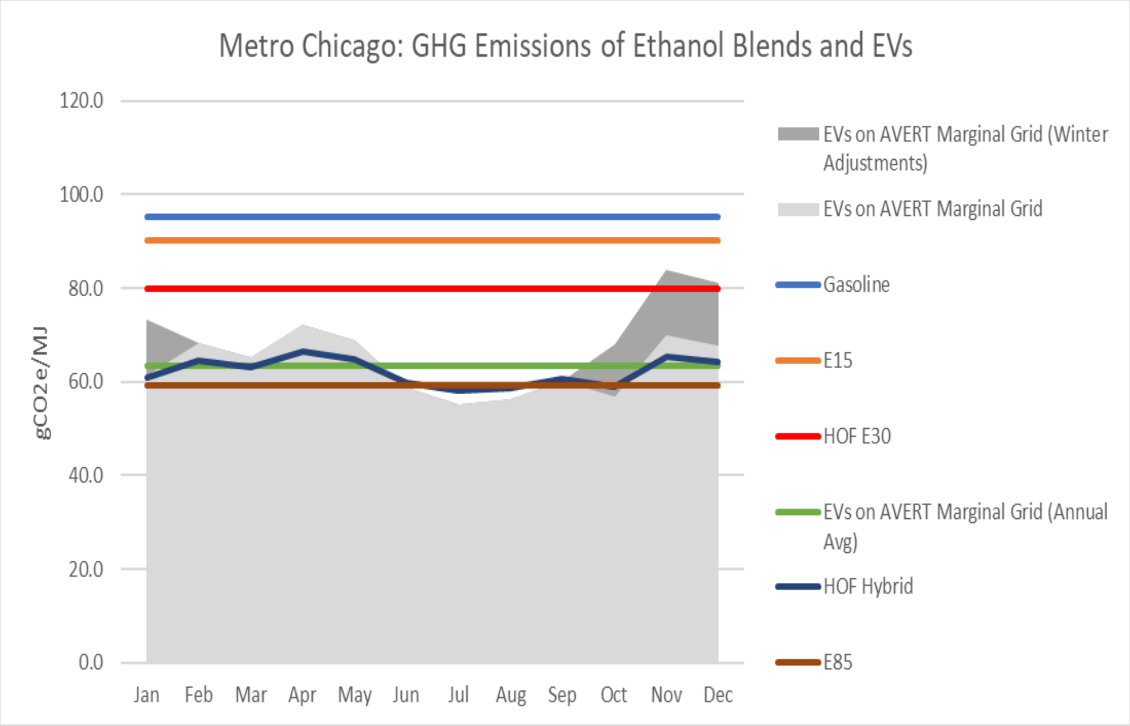
	Gasoline E0	Gasoline E10	California Average (Baseload)	California Marginal (eGRID Non Baseload)	US Baseload Average (eGRID)	US Marginal (eGRID Non Baseload)	Marginal Midwest (AVERT)	Coal Grid	HOF E20 (3% EER)	HOF E20 (5% EER)	HOF E30 (8% EER)	HOF E30 (8% EER) CCS	E85	E85 with CCS
BEV			100	186	190	288	367	467						
E10		415												
E0	445													
HOF									388	380	354	325	274	173

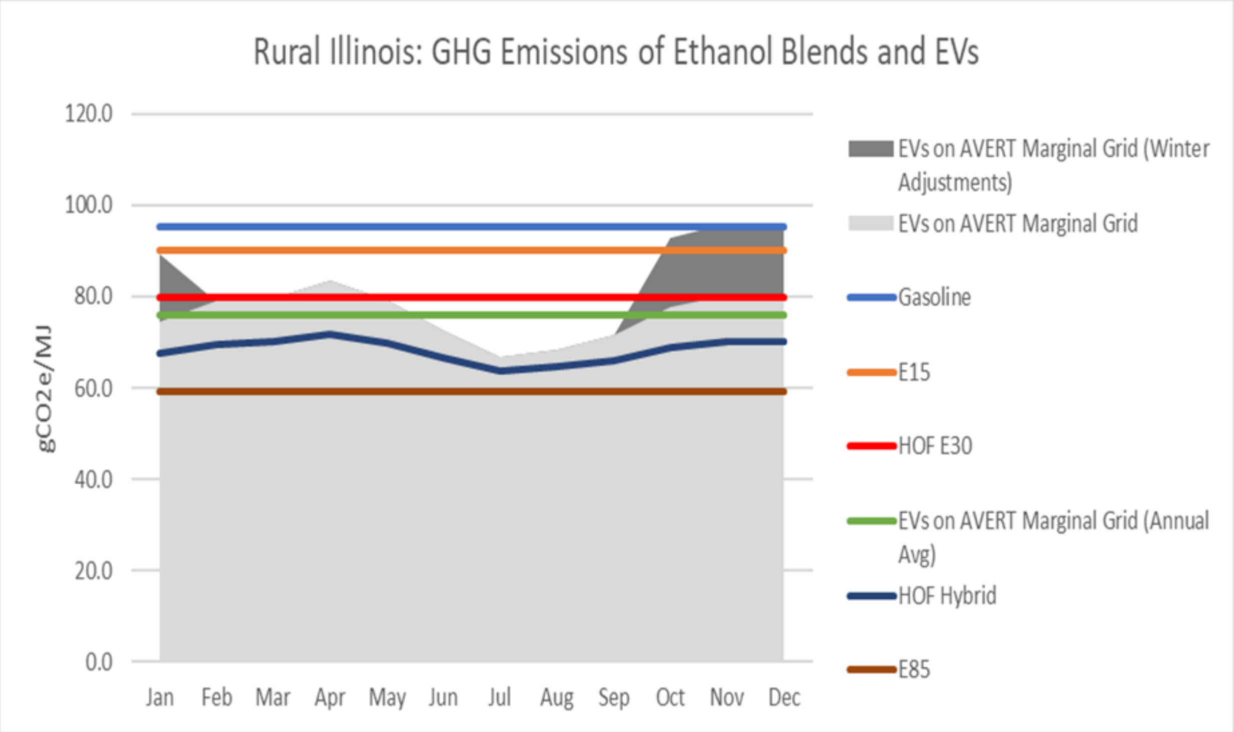
Results: Metro Chicago vs. Rural Illinois

The light grey area represents the carbon intensity of EVs charged on the local, marginal electricity mix by month. The darker sections of the curve represent an additional penalty assigned to EVs for inefficiencies during winter charging.

Results for Metro Chicago which is connected to the Midwest AVERT* Region.

Rural Illinois which is connected to the Mid-Atlantic AVERT* Region.





Driving Modes

EVs provide less benefits on highway driving cycles

The comparison of life cycle GHG emissions across vehicle types can depend heavily on the type of driving the vehicle will do. (Source: Karabasoglu)

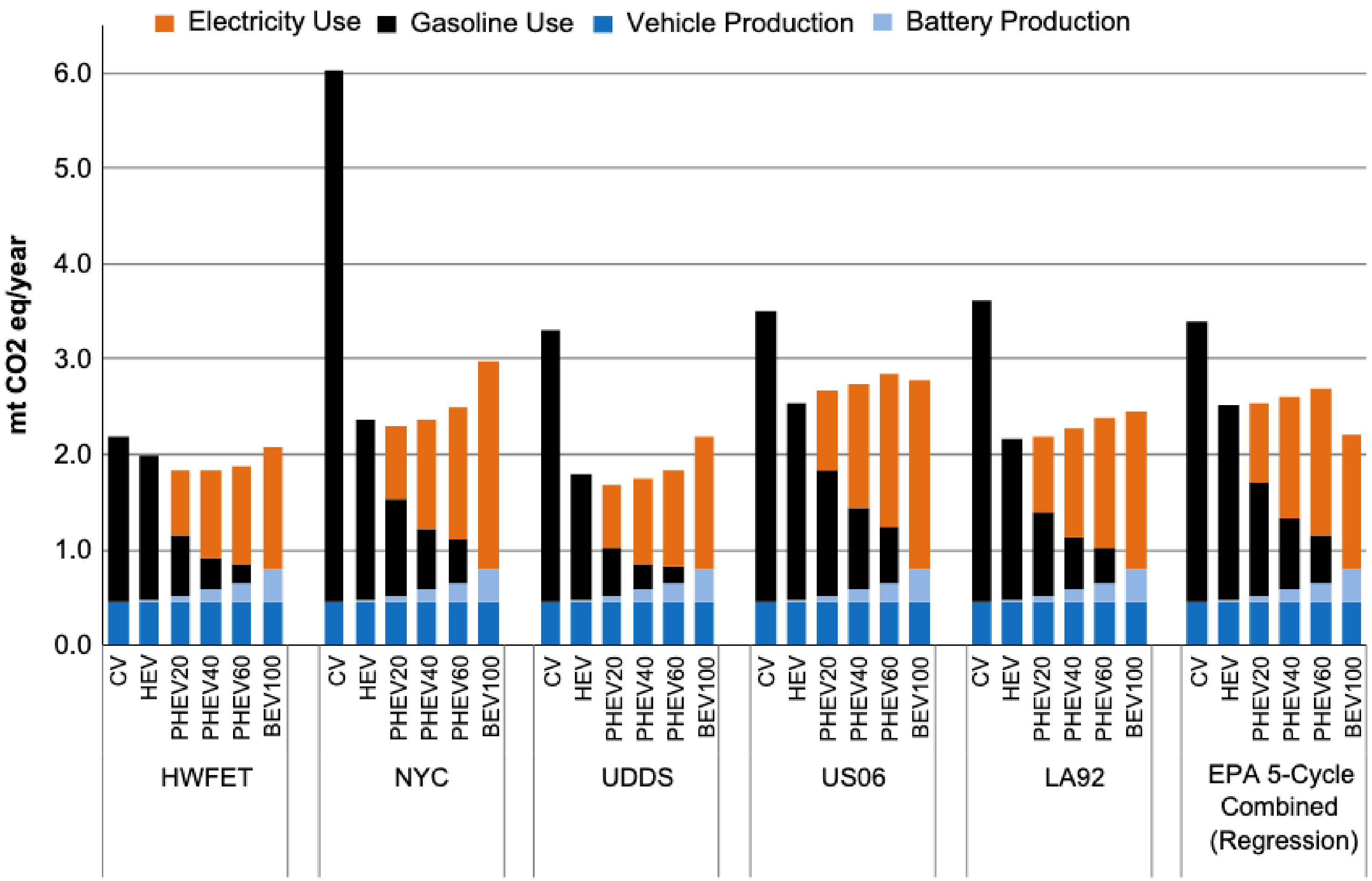


Fig. 8. NHTS-Averaged Annual GHG Emissions per Vehicle (Base Case).

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Findings: GHG Emissions

- EVs and Biofuels technologies provide significant GHG savings over gasoline vehicles
- GHG savings from EVs depend on carbon intensity of incumbent electricity grid.
    - Transition to clean electricity (see California) is important
- GHG grid carbon intensity varies between northern IL and rest of the state
- In rural areas hybrid technologies and especially hybrids with biofuels provide significant GHG benefits

Particulate Matter Emissions and Environmental Equity

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Urgency to Reduce PM 2.5

The Washington Post

Climate and Environment

Deadly air pollutant 'disproportionately and systematically' harms Americans of color, study finds

Black, Latino and Asian Americans face higher levels of exposure to fine particulate matter from traffic, construction and other sources

By Juliet Eilperin and Darryl Fears

April 28, 2021 at 1:00 p.m. CDT

The findings of researchers from five universities, published in the online journal Science Advances, provide the most detailed evidence to date of how Americans of color have not reaped the same benefits as White Americans, even though the country has made major strides in curbing pollution from cars, trucks, factories and other sources. The particles studied have diameters of no more than 2.5 micrometers — one-thirtieth the width of a human hair — and can become embedded in the lungs. Known as Particulate Matter (PM) 2.5, they account for between 85,000 and 200,000 premature U.S. deaths each year.

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Urgency to Reduce PM 2.5

Journal List > Elsevier Public Health Emergency Collection > PMC7835077

Elsevier Public Health Emergency Collection

Public Health Emergency COVID-19 Initiative

Respir Med. 2021 Mar; 178: 106313.
Published online 2021 Jan 26. doi: 10.1016/j.rmed.2021.106313

PMCID: PMC7835077
PMID: 33550152

Long-term exposure to fine particulate matter and hospitalization in COVID-19 patients

Angelico Mendy,[a,*] Xiao Wu,[b] Jason L. Keller,[c] Cecily S. Fassler,[a] Senu Apewokin,[d] Tesfaye B. Mersha,[e] Changchun Xie,[f] and Susan M. Pinney[a]

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Article | Open Access | Published: 28 January 2021

Particulate matter ($PM_{2.5}$) as a potential SARS-CoV-2 carrier

Norefrina Shafinaz Md Nor, Chee Wai Yip, Nazlina Ibrahim, Mohd Hasni Jaafar, Zetti Zainol Rashid, Norlaila Mustafa, Haris Hafizal Abd Hamid, Kuhan Chandru, Mohd Talib Latif, Phei Er Saw, Chin Yik Lin, Kemal Maulana Alhasa, Jamal Hisham Hashim & Mohd Shahrul Mohd Nadzir

Scientific Reports **11**, Article number: 2508 (2021) | Cite this article

Observational Study › Int J Environ Res Public Health. 2020 Dec 13;17(24):9318.
doi: 10.3390/ijerph17249318.

Associations between COVID-19 Incidence Rates and the Exposure to PM2.5 and NO $_2$: A Nationwide Observational Study in Italy

Fabiana Fiasca [1], Mauro Minelli [2] [3], Dominga Maio [2], Martina Minelli [2], Ilaria Vergallo [2], Stefano Necozione [1], Antonella Mattei [1]

Affiliations + expand

PMID: 33322089 PMCID: PMC7763344 DOI: 10.3390/ijerph17249318

Free PMC article

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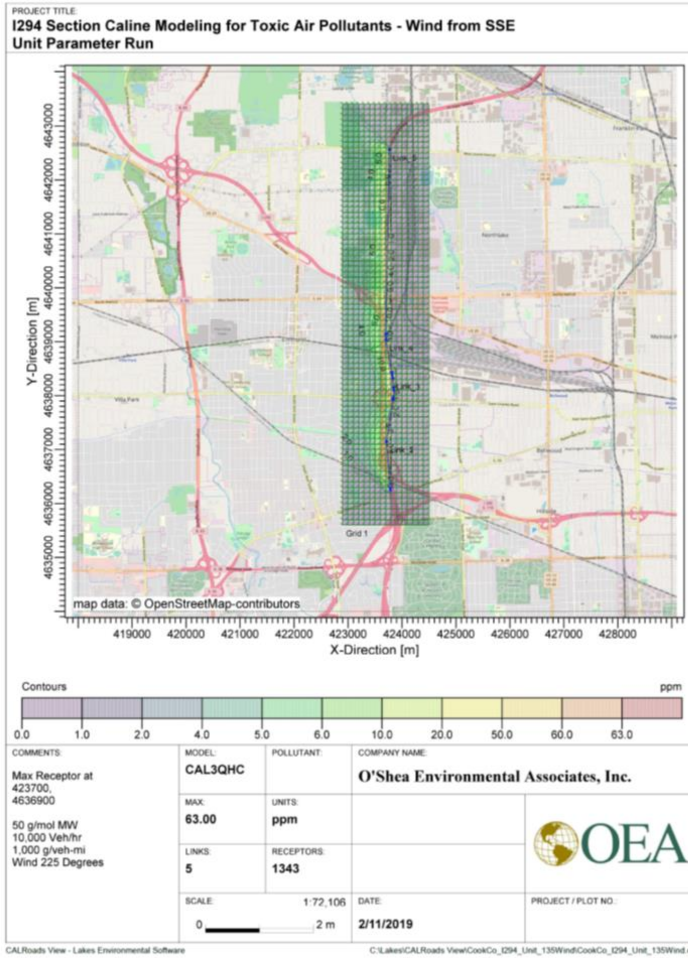
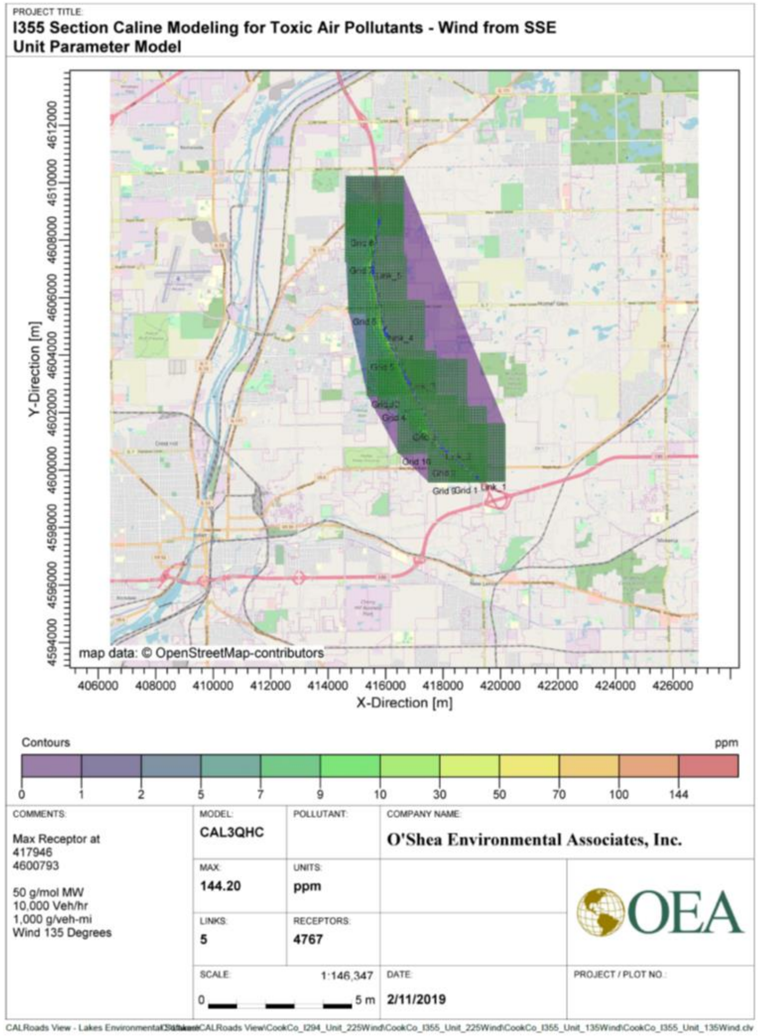
Cal3QHC Model

Calibration over Chicago used to determine dispersion from mobile sources

Highest concentration of tailpipe PM and Air Toxins within 0.2 miles of line source





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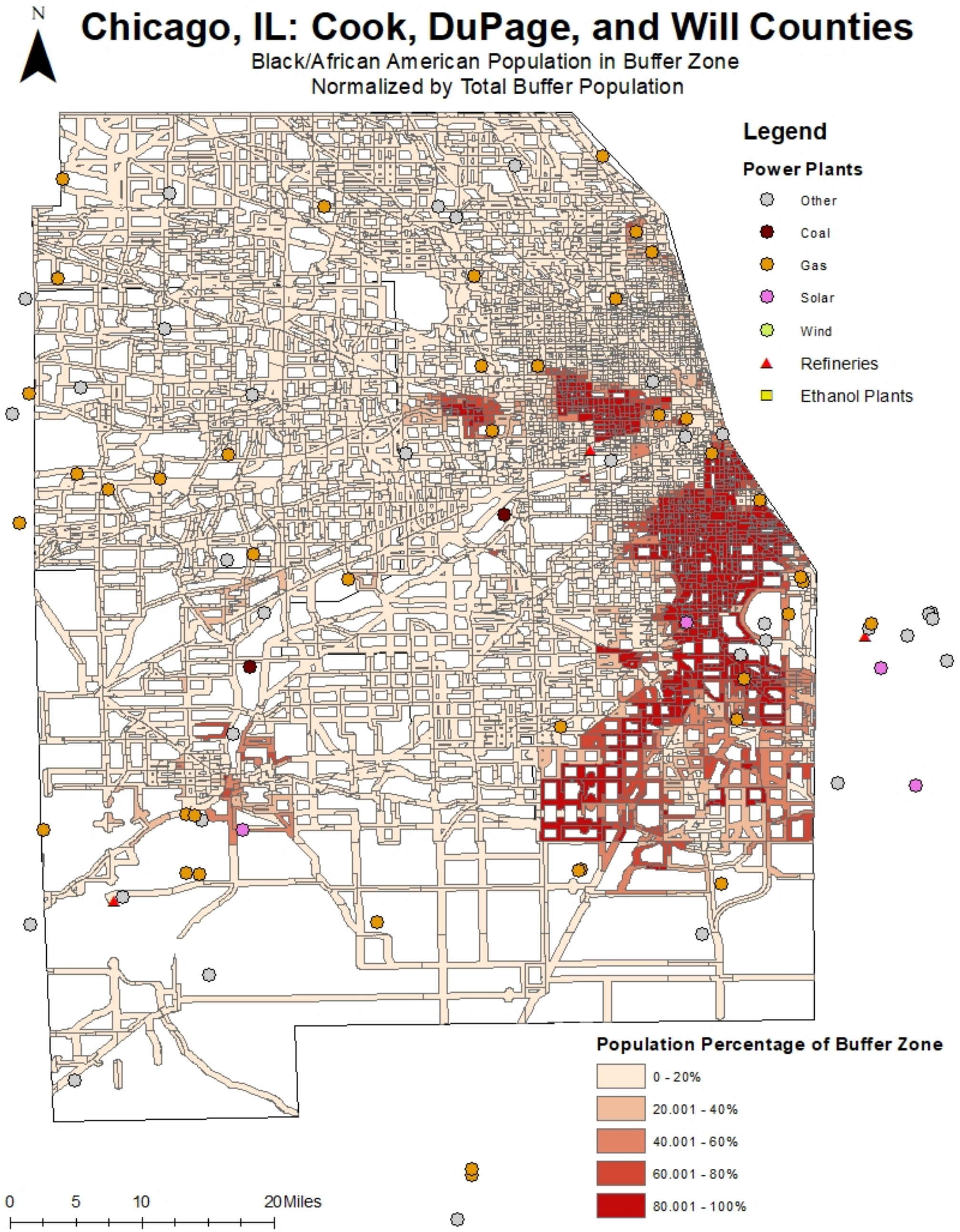
Chicago

- Higher percentage of black population living within expressway buffers

Buffer Area			
Total Population	6671740		
White Population	3163989		
White Percent	47	Percent of Census Tract White Population Living in Buffer Area	76
Black Population	1192312		
Black Percent	18	Percent of Census Tract Black Population Living in Buffer Area	85



Findings: Particulate Matter Emissions and Environmental Equity

- Tailpipe PM emissions settle close to line source (major roadways)
- Population next to major roadways are over-proportionally exposed to pollutants.
- EV and Biofuel Vehicles can Reduce toxic emissions from Particulate Matter and Aromatic Hydrocarbons

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Overall Summary

- Difference in electricity regions are significant in Illinois: Pollution intensity higher in central/southern grid region vs. northern grid region including metro Chicago
  - GHG reductions from EVs are higher in northern region
  - Plug-in hybrids with biofuels is a preferred technology for central/southern Illinois
- Difference in urban vs. rural population
  - In Chicago over-proportional concentration of minority population groups live near expressways
  - Clean fuels (electricity and biofuels) reduce criteria pollutants next to expressways

Additional Slides

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Electricity Emissions Aggregation

Difference: Marginal vs. Average Grid Emissions Factor

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EPA Published AVERT marginal emission factors for each AVERT region.

We compared those marginal factors to EPA's average eGRID factors (adjusted for transmission loss). EPA eGrid is used in many EV charging calculator tools.

	AVERT Region	Avert 2019 lbs/MWh*	eGrid Region	eGRID 2018 lbs/MWh**	eGRID with Transmission Loss
Colorado	Rocky Mountain	1,904	RMPA	1,171	1,231
Illinois - Chicago	Mid-Atlantic	1,540	RFCW	1,174	1,234
Illinois - Rural	Midwest	1,860	SRMW	1,677	1,763
Indiana	Midwest	1,860	RFCW	1,174	1,234
Iowa	Midwest	1,860	MROW	1,249	1,313
Kansas	Central	1,800	SPNO	1,172	1,232
Kentucky	Midwest	1,800	SRTV	1,038	1,091
Michigan	Midwest	1,860	RFCM	1,321	1,389
Minnesota	Midwest	1,860	MROW	1,249	1,313
Missouri	Midwest	1,860	SRMW	1,677	1,763
Nebraska	Central	1,800	MROW	1,249	1,313
North Dakota	Midwest	1,860	MROW	1,249	1,313
Ohio	Mid Atlantic	1,540	RFCW	1,174	1,234
South Dakota	Midwest	1,800	MROW	1,249	1,313
Wisconsin	Midwest	1,860	RFCW,MROWE/MROW	1,420	1,493

***already adjusted for transmission loss**

****eGrid Output factors not adjusted for transmission loss**

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Criteria Pollutants

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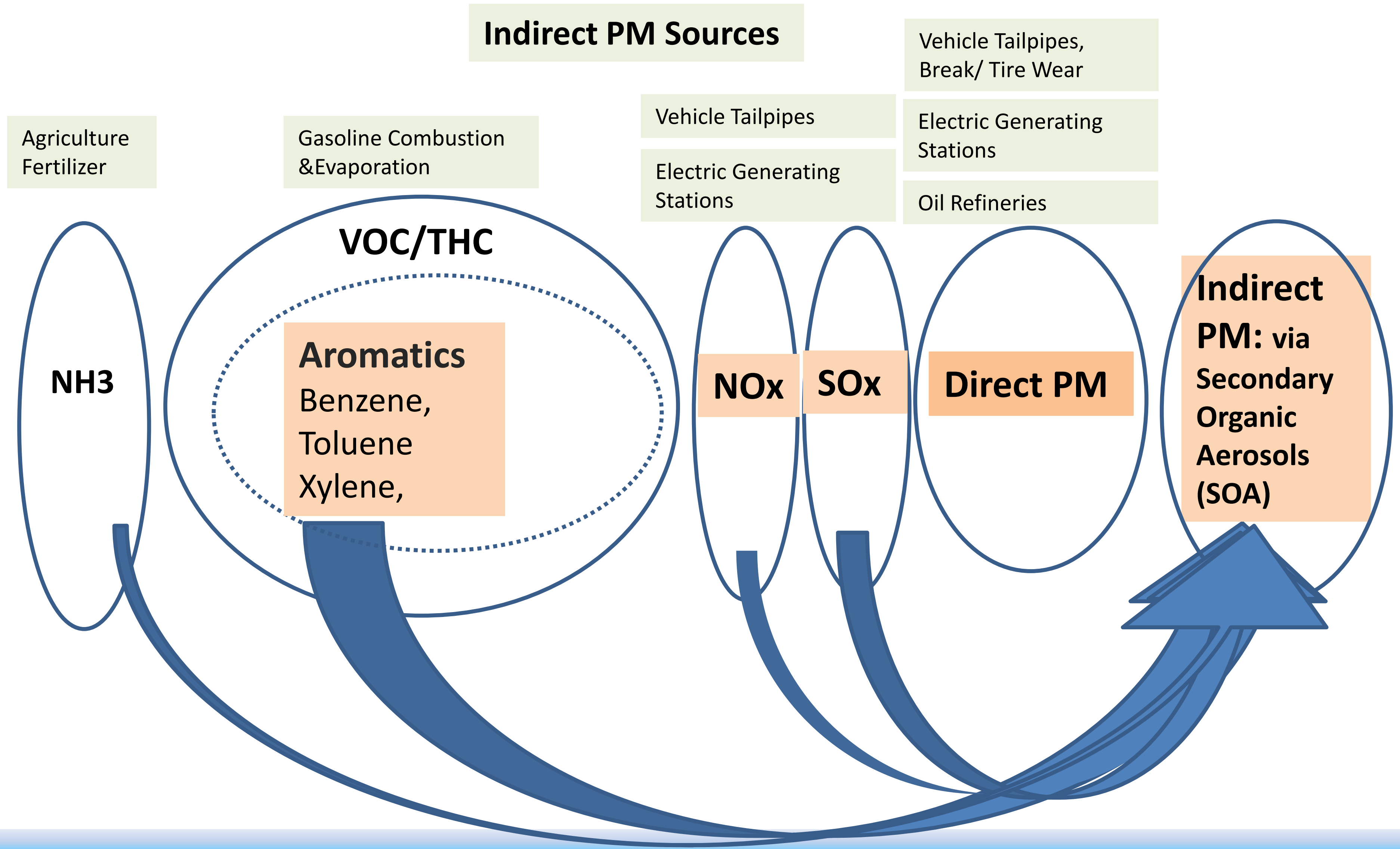
Significant Emissions Benefits in Lessor Mentioned Areas



Contact

Steffen Mueller, PhD
Principal Economist
Energy Resources Center
The University of Illinois at Chicago
1309 South Halsted Street
Chicago, IL 60607
(312) 316-3498
muellers@uic.edu

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